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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/887,199	06/21/2001	Ivo Raaijmakers	ASMMC.005AUS	7254

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EXAMINER	
MAI, ANH D	

ART UNIT	PAPER NUMBER
2814	

DATE MAILED: 03/04/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/887,199	RAAIJMAKERS ET AL.	
	Examiner	Art Unit	
	Anh D. Mai	2814	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *05 November 2003 and 08 December 2003*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-19* is/are pending in the application.

4a) Of the above claim(s) *2-5* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1 and 6-19* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

Status of the Claims

1. Amendments filed November 5, 2003 and December 8, 2003 has been entered. Claims 1, 13 and 14 have been amended. Claims 1-19 are pending. Claims 2-5 have been withdrawn.

Claim Rejections - 35 USC § 103

The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

2. Claims 1 and 6-19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Gates et al., (U.S. Patent No. 6,203,613) of record and M. Ritala et al., *Perfectly Conformal TiN and Al_2O_3 Films Deposited by Atomic Layer Deposition*, of record (IDS, Paper No. 4).

Gates teaches a method of fabricating trench isolation structures between integrated electrical devices in a semiconductor substrate substantially as claimed including:

placing a semiconductor substrate in a reaction chamber, the semiconductor substrate comprising trenches; and

filling the trenches with insulating material (metal-containing film) by atomic layer deposition (ALD), the ALD process comprising a plurality of primary cycle, each primary cycle comprising, in sequence:

introducing a first vapor-phase reactant (1st metal precursor) to the substrate, thereby forming no more than about one monolayer of a first reactant species conforming at least to surface of the trenches;

removing (inert purge) excess first vapor-phase reactant and byproduct from the reaction chamber;

introducing a second vapor-phase reactant (co-reactant) to the substrate, thereby reacting with the first reactant species conforming at least to the surfaces of the trenches; and

removing (inert purge) excess second vapor-phase reactant and by product from the reaction chamber. (See particularly col. 6, lines 22-33).

Thus, Gates is shown to teach all the features of the claim with the exception of explicitly disclosing that the trench is completely filled.

However, Ritala teaches that trenches formed in a semiconductor substrate can be completely filled with insulating material (Al_2O_3) using ALD process to form a trench isolation structure. (See Figs. 1).

Therefore, it would have been obvious to one having ordinary skill in the art at the time of invention to completely fill the trenches formed in the semiconductor substrate of Gates as taught by Ritala to form a trench isolation structure because uniformity and conformality are inherent result of ALD, thus, keyhole formation is avoided. (See Ritala, page 7).

With respect to the term "thereby forming no more than about one monolayer of a first reactant species conforming at least to surface of the trenches", the ALD results in one layer per cycle, thus, the term is met.

With respect to the term "thereby reacting with the first reactant species conforming at least to the surfaces of the trenches", since the second vapor-phase reactant of Gate is co-reactant, the term, thereby reacting, is met.

With respect to claim 6, the ALD of Gate further including a plurality of secondary cycles, each secondary cycle comprising, in sequence:

introducing a third vapor-phase reactant (2^{nd} precursor) to the substrate, thereby forming no more than about one monolayer of a third reactant species conforming at least to surfaces of the trenches, the third reactant species being different from tile first reactant species;

removing (inert purge) excess third vapor-phase reactant and byproduct from the reaction chamber,

introducing a fourth vapor-phase reactant (co-reactant) to the substrate, thereby reacting the third reactant species conforming at least to the surface of the trenches; and

removing (inert purge) excess fourth vapor-phase reactant and byproduct from the reaction chamber. (See col. 6, lines 25-33).

With respect to claim 7, although Gates does not disclose the specific reactants as claimed, however, Gates clearly discloses that, metal-containing precursor having the formula $M(NO_3)x$, wherein M is a metal selected from the group including Si and Al and co-reactant gas includes oxidizing agent (col. 4, lines 40-51).

With respect to claim 8, the metal source gas of Gates also includes metal-alkyl compounds and the oxidant source gas includes water, thus, the limitation of the claim is met.

With respect to claim 9, the filling of the trench of Gates in view of Ritala consists of mixing the primary cycle and secondary cycles and the mixing ratio (alternate 1:1) is within the claimed ratio between about 20:1 and 1:10.

With respect to claim 10, the primary cycles of Gates deposit a first oxide species and the secondary cycle deposit a second oxide species. (See col. 9, lines 5-14).

With respect to claim 11, the first oxide species of Gates is silicon oxide and the second oxide species is a metal oxide. (See Example 4).

With respect to claim 12, the second oxide species of Gates also includes aluminum oxide. (See col. 4, lines 40-51).

With respect to claims 13 and 14, the method of Gates includes any combination of multiplayer metal oxide film to form an insulation layer.

Note that the specification contains no disclosure of either the *critical nature of the claimed composition* (23% + 37%, claim 13 and 26% +34%, claim 14) *of any unexpected results arising therefrom*. Where patentability is aid to based upon particular chosen dimension or upon another variable recited in a claim, the Applicant must show that the chosen dimension are critical. *In re Woodruff*, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990).

Since ALD process can form monolayer-by-monolayer, therefore, it would have been obvious to one having ordinary skill in the art at the time of invention to form the multiplayer metal oxide of Gates, in view of Ritala, in any combination to achieve a superior isolation.

With respect to claim 15, at least a portion of the first and second oxide species of Gates inherently combine to form a separate phase appears to be in equilibrium with a portion of the first oxide.

With respect to claim 16, since the multiple ALD layer also includes silicon oxide and aluminum oxide as contemplated by Gates, thus, the separate phase of Gates also comprises mullite. Mullite is a mixture described as: $3Al_2O_3*2SiO_2$. Another word, any five layer of metal oxide including three layer of Al_2O_3 sandwiched by two layer of SiO_2.

With respect to claim 17, similar to claims 13 and 14 above, the method of Gates includes any combination of multiplayer metal oxide film.

Note that the specification contains no disclosure of either the *critical nature of the claimed composition* (25% mullite and 50% mullite by weight) *of any unexpected results arising therefrom*. Where patentability is aid to based upon particular chosen dimension or upon another variable recited in a claim, the Applicant must show that the chosen dimension are critical. *In re Woodruff*, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990).

Since ALD process can form monolayer-by-monolayer, therefore, it would have been obvious to one having ordinary skill in the art at the time of invention to form the multiplayer metal oxide of Gates, in view of Ritala, in any combination to achieve a superior isolation.

With respect to claim 18, since silica and alumina have been contemplated by Gates for the metal-oxide insulator (see col. 4, line 40-51), these metal-oxide can be alternatively deposited (e.g., at least 1:1). This ratio is within the disclosed ratio (20:1 to 1:10) to achieve a coefficient

of thermal expansion (CTE) within about 20% of silicon's CTE. (See specification page 19, line 23-25).

With respect to claim 19, Gates does not explicitly disclosing mixing of the primary cycle and secondary cycle to achieve a coefficient of thermal expansion (CTE) within about 10% of silicon's CTE.

However, the specification contains no disclosure of either the *critical nature of the claimed coefficient of thermal expansion within 10% of the semiconductor substrate's CTE* of any unexpected results arising therefrom. Where patentability is aid to based upon particular chosen CTE or upon another variable recited in a claim, the Applicant must show that the chosen dimension are critical. *In re Woodruff*, 919 F.2d 1575, 1578, 16 USPQ2d 1934, 1936 (Fed. Cir. 1990).

Therefore, it would have been obvious to one having ordinary skill in the art at the time of invention to fill the trenches such that CTE of the insulating material should closely match that of the semiconductor substrate to prevent a large thermal stress on the semiconductor substrate which is a main cause of failure, such as cracking.

Response to Arguments

3. Applicant's arguments filed November 5, 2003 have been fully considered but they are not persuasive.

Applicants argue that there is no teaching or suggest in Gates that would motivate one of skill in the art to attempt to form a trench isolation structure by an ALD process.

However, in addressing the filling of trench using ALD, Gates clearly teaches: "Also, the conformality of ALD nitride films inside small vias (100-300 nm diameter) and trenches is excellent (nearly 100% step coverage)" (col. 5, ll. 16-24). This alone has already provided more than enough suggestion and motivation to fill the trench using ALD, although not specifically about STI.

Regarding the reference to Ritala, Applicants argue that while Ritala utilizes trenches to demonstrate the conformal nature of ALD, there is no teaching or suggestion in Ritala of completely filling those trenches by ALD to form trench isolation structures between integrated electrical devices in a semiconductor substrate, as claimed.

However, Ritala teaches: "In conclusion, the perfect conformality of two thin film materials, TiN and AIzO3, deposited by ALD was demonstrated. The surface-controlled, self-limiting film growth mechanism of ALD makes it possible to deposit films uniformly into deep trenches, and the trenches may also **be filled completely without keyhole formation**" (see page 8).

Regarding the criticality of the claimed combination of materials, given the silica-mullite phase diagram from W.E.Lee and W.M. Rainforth, one having ordinary skill in the art ordinary skill in the art should be able to determined the composition of the multilayer film to achieve a CTE of 20% silicon or less. Further, these are chosen dimensions, not as an unexpected result arriving form an unknown parameters. (See phase diagram).

Finally, neither criticality nor unexpected results are supported by the specification.

Conclusion

4. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Anh D. Mai whose telephone number is (571) 272-1710. The examiner can normally be reached on 9:00AM-5:00PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Wael Fahmy can be reached on (571) 272-1705. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR

system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

A.M
February 23, 2004

SUPERVISORY PRIMARY EXAMINER
TECHNOLOGY CENTER 2800